Space Weather Technical Forecast

Issued on Monday, 10 July 2023 at 13:11 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: G1/Minor Storm likely, chance of G2/Moderate Storm on 12-13 July with CME arrival. Chance of R1/R2 radio blackouts throughout. Slight chance of fluence becoming Active (1e8 integrated pfu).

Analysis of Space Weather Activity over past 24 hours
Solar Activity: Solar activity has been Moderate, with an M2.3 flare peaking at 10/0355 UTC from the sunspot complex in the southwest, most likely from AR3366. There are currently ten active regions on the visible disc. AR3361 in the northwest is the most magnetically complex region, with a small delta spot. AR3363 is the largest region in the southeast, but has lost its weak trailing spot so is now one large unipolar spot. AR3366, AR3368 and AR3369 are all close together in the southwest, with some magnetic interaction between these regions, likely increasing instability. AR3367 continues to evolve, but doesn't have any obvious significant complexity at the moment. The new region on the southeast limb is not yet fully visible. The other regions appear to be small and simple at present.
A partial halo CME associated with the M2 flare was seen travelling towards the southwest in coronagraph imagery. Evaluation is still ongoing, but an Earth directed component is considered probable.

Solar Wind / Geomagnetic Activity: The solar wind as observed at L1 by ACE, was at ambient levels throughout. Wind speeds varied between 330-390 km/s. The density was below average. Total magnetic field strength has been weak throughout below 6 nT, whilst the north-south component also varied weakly. The phi angle has been mostly positive (away from the Sun). Geomagnetic activity has been at Quiet levels throughout (Kp 0-2).

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as observed by GOES16, has been well below the S1/Minor Storm level, but is very slightly raised above the normal background. High energy electron flux (greater than 2MeV), as observed by GOES16, was at mostly moderate levels, with a peak of 861 pfu at 09/1450 UTC. The 24-hour integrated fluence was below the Active (1e8 integrated pfu) threshold on a steady trend. A fluence of 4.16e7 pfu was recorded at 10/0000UTC.

Four-Day Space Weather Forecast Summary
Solar Activity: Low to Moderate solar activity is most likely through the period, with a slight chance of an isolated X-class flare.

Solar Wind / Geomagnetic Activity: A partial halo CME associated with the M2 flare at 10/0355 UTC was seen travelling towards the southwest in coronagraph imagery. Evaluation is still ongoing, but an Earth directed shock component is considered probable. At this stage, an arrival time of around 13/0000 UTC is most likely, but confidence is low. The solar wind is currently at slow-ambient levels and is likely to remain that way until the CME arrival. As the CME effects continue, a HSS from CH23/- is likely to arrive during Day 4 (13 July). The combination of CME effects and HSS could lead to increased geomagnetic impacts. Geomagnetic activity is forecast to be Quiet to Unsettled at first, increasing to Active to G1/Minor

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Storm with a chance of G2/Moderate Storm due to CME and HSS effects on Days 3 or 4 (12-13 July).

Energetic Particles / Solar Radiation: The high energy (greater than 10MeV) proton flux has a slight chance of reaching the S1/Minor Storm threshold through the period, should any larger flares occur. High energy electron flux (greater than 2MeV) is likely to reach moderate levels at first, with a sharp decline during Days 3-4 (12-13 July) as the anticipated CME arrives. Electron fluence has a slight chance of reaching Active (1e8 integrated pfu), before dropping during Days 3-4 with the CME arrival.

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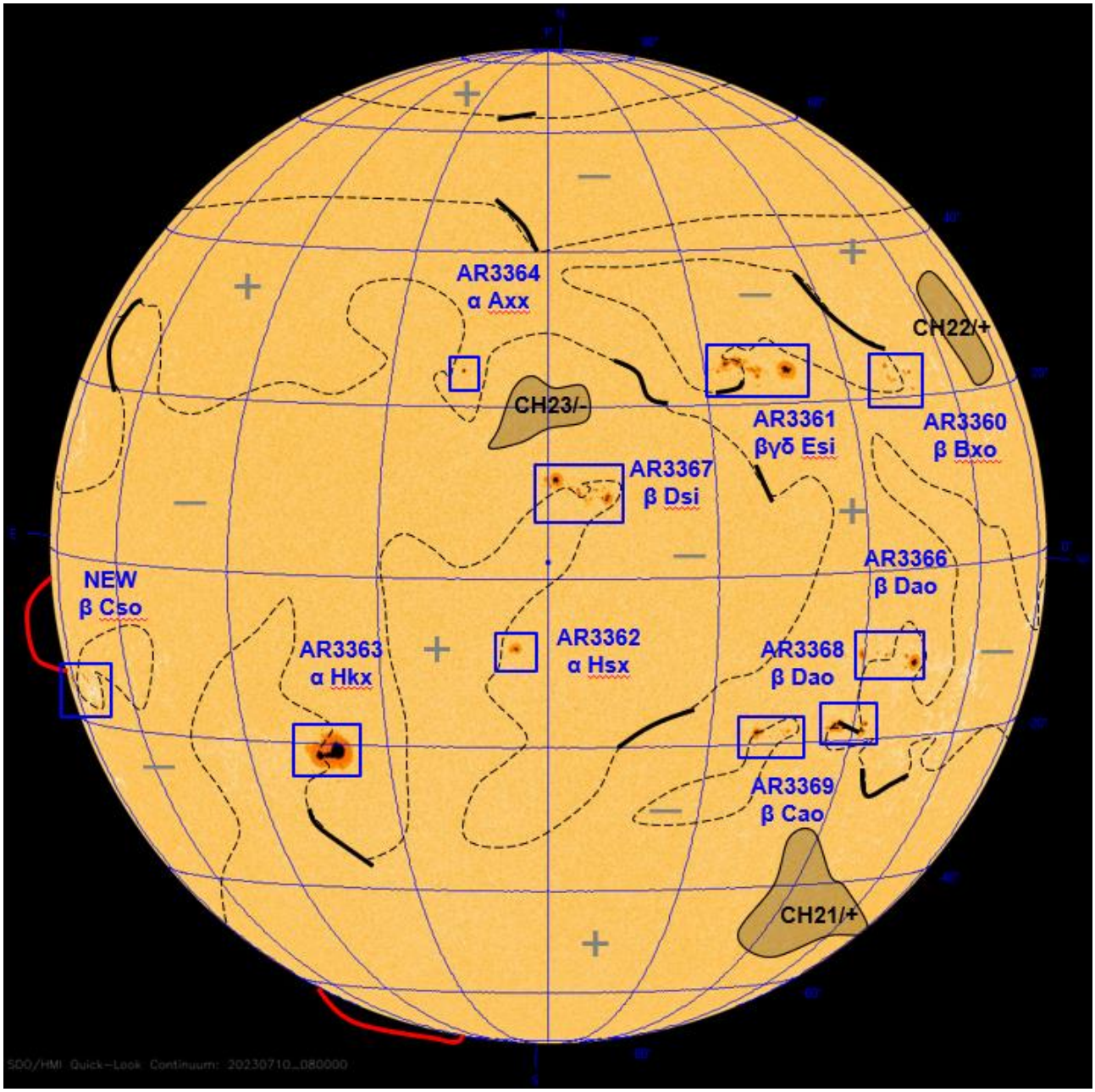
Figure 1. Solar Analysis Valid 10/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A partial halo CME associated with the M2 flare at 10/0355 UTC was seen travelling towards the southwest in coronagraph imagery. There was also a fainter assymmetric full halo from the shock. Evaluation is still ongoing, but although the bulk of the CME is expected to pass ahead of Earth, an Earth directed shock component is considered probable. At this stage, an arrival time of around 13/0000 UTC is most likely, but confidence is low.

The solar wind is currently at slow-ambient levels and is likely to remain that way until the CME arrival. As the CME effects continue, a HSS from CH23/- is likely to arrive during Day 4 (13 July), or perhaps just after the end of this period. On the previous rotation this feature resulted in solar winds reaching 600-700 km/s, and a maximum geomagnetic response of G2 / Moderate storm. On this rotation the feature appears smaller and more fragmented in appearance, and this will probably lead to lower solar wind levels and associated impacts. However, the combination of CME effects and HSS could lead to increased geomagnetic impacts.

Geomagnetic activity is forecast to be Quiet to Unsettled at first, increasing to Active to G1/Minor Storm with a chance of G2/Moderate Storm due to CME and HSS effects on Days 3 or 4 (12-13 July).

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	1	1	30	60
Strong	G3	No	1	1	5	10
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
10/0750 UTC	Partial	AR3366	SW	900 km/s	13/0000 UTC	Confidence low in timings. Shock impact more likely than main CME.

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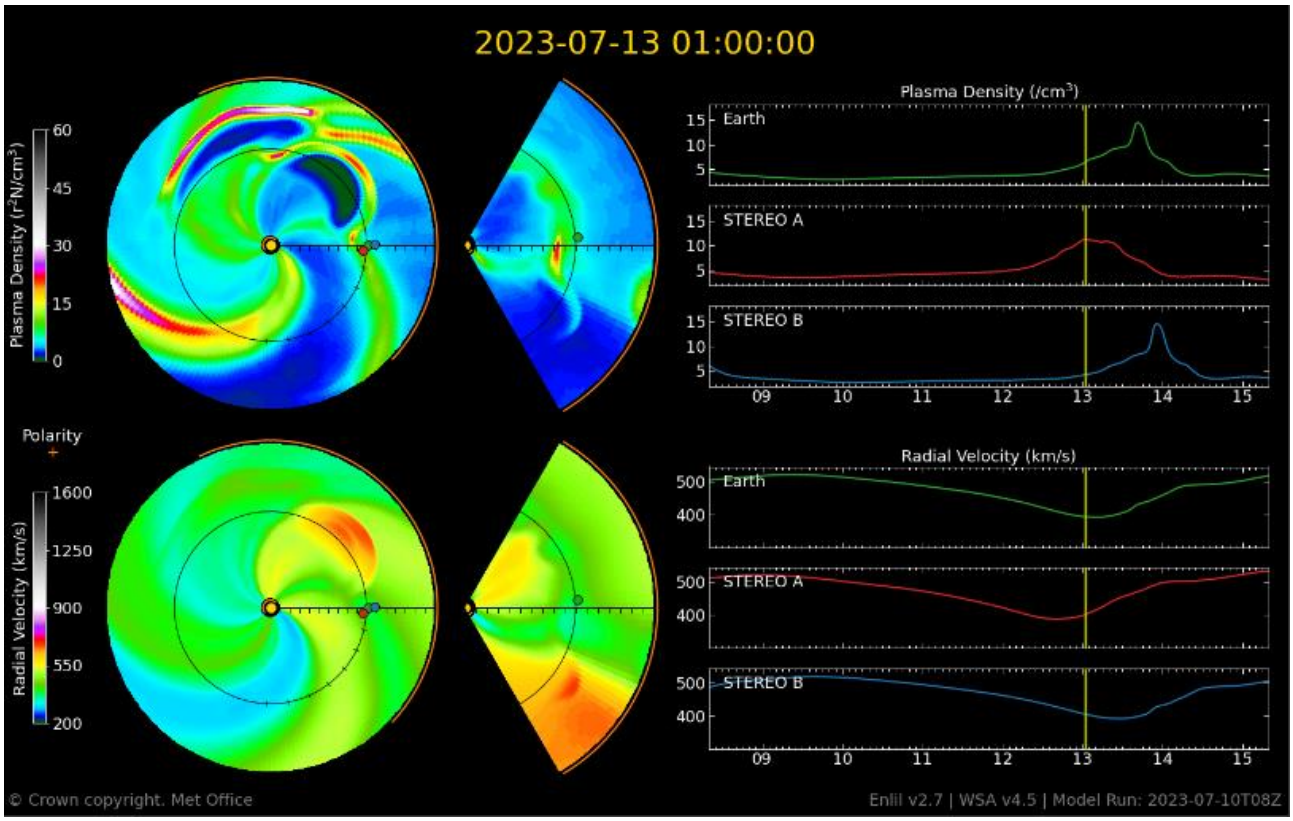
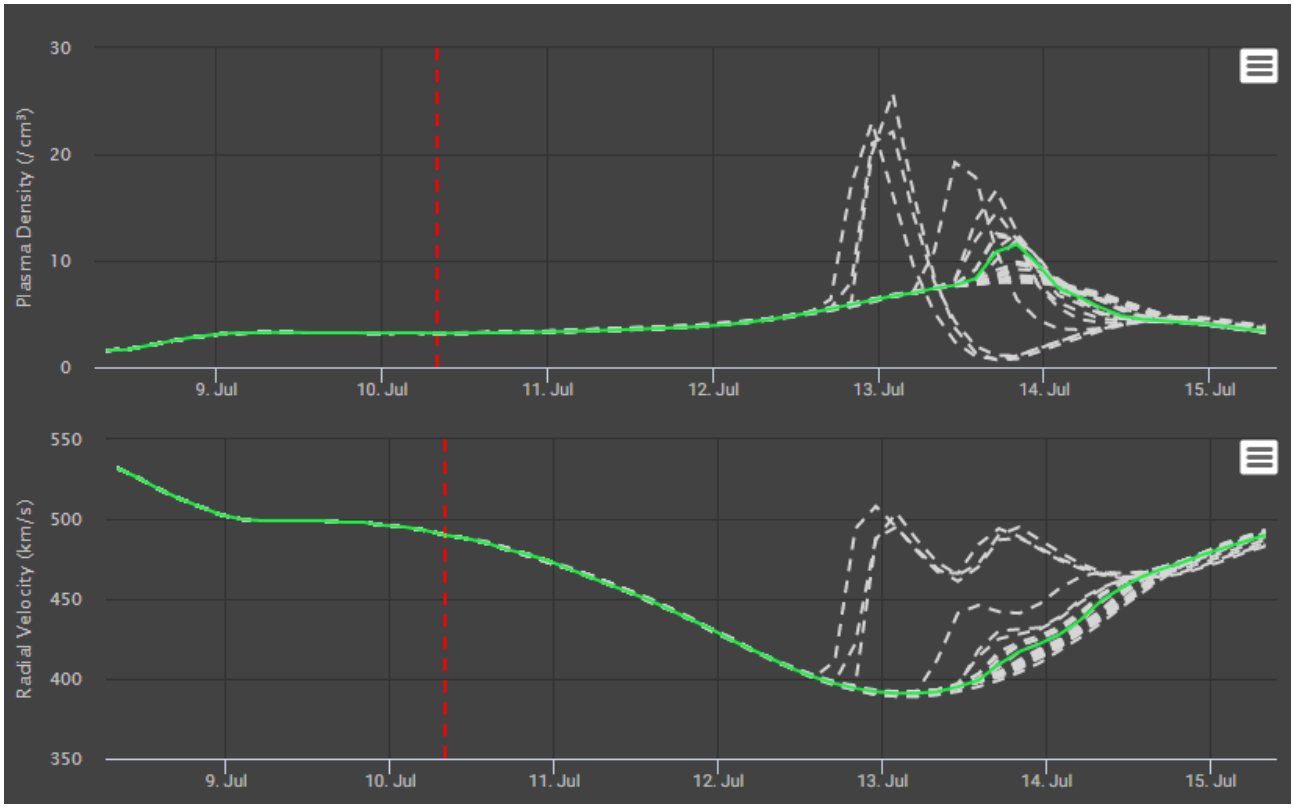
Figure 2: MOSWOC Enlil and ensemble showing CME just glancing Earth, perhaps early on 13 July, although confidence in timing is currently low. Only the main part of the CME is modelled here, but a wider faint shock was visible in imagery which is likely to impact Earth.





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Radio Blackouts - X-Ray Flares:
Solar activity has been Moderate, with an M2.3 flare peaking at 10/0355 UTC from the complex in the southwest, most likely from AR3366.

There are currently ten active regions on the visible disc. AR3361 (Esi/Beta-Gamma-Delta) in the northwest is the most magnetically complex region, with a small delta spot. AR3363 (Hkx/Alpha) is the largest region in the southeast, but has lost its weak trailing spot so is now one large unipolar spot. AR3366 (Dao/Beta), AR3368 (Dao/Beta) and AR3369 (Cao/Beta) are all close together in the southwest, with some magnetic interaction between these regions, likely increasing instability. AR3367 (Dsi/Beta) continues to evolve, but doesn't have any obvious significant complexity at the moment. The new region on the southeast limb is not yet fully visible. The other regions appear to be small and simple at present. Low to moderate activity is likely, with a slight chance of an isolated X-class flare.

No major active region is forecast to depart the visible disc during the period and far side sounding data suggests that further regions may rotate onto the disc during the coming days. As these regions rotate across the eastern limb the flare probabilities have been raised a little for days 3 and 4.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	50	50	60	60
Very Active	R3 to R5 X Class	No	10	10	10	10

Figure 3: GOES16 X-ray flare trace from the last 24 hours.

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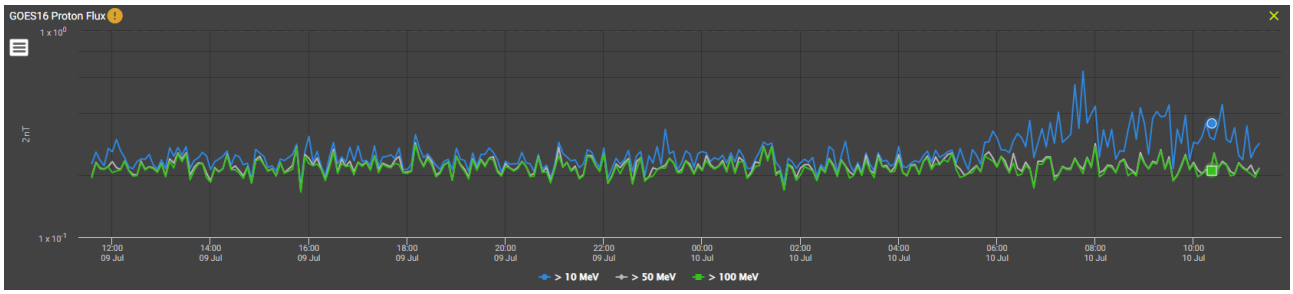
Solar Radiation Storms - (High Energy Protons):
The high energy (greater than 10MeV) proton flux, as observed by GOES16, is currently near background levels, although very slightly raised in the wake of the M2 flare earlier today. There is a slight chance of S1/Minor storm levels being reached through this period, should any larger flares occur mainly from regions in the western hemisphere. The probability has been increased slightly, due to the current slightly raised activity.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	10	10	10
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

Figure 4: GOES15 proton flux, showing a very slightly raised 10MeV signature (well below the S1/Minor Storm threshold).



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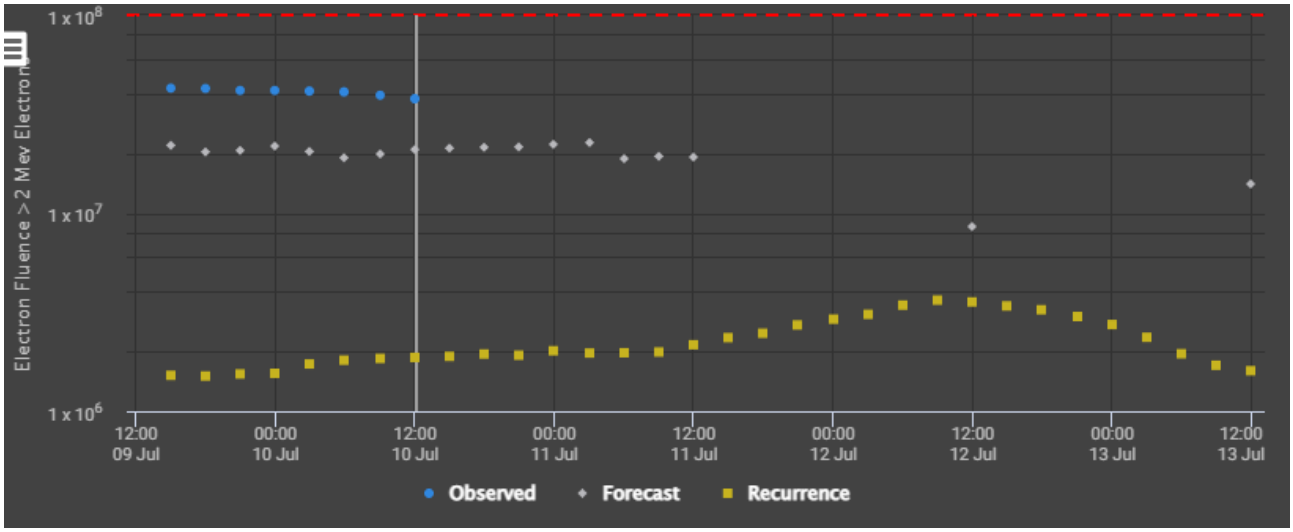
High Energy Electrons Event (≥ 2MeV):
High energy electron flux (greater than 2MeV) has remained at moderate levels in recent days. The BAS radiation belt model suggests only a limited increase in electron flux has taken place below GEO, probably due to the recent HSS. Electron flux is now considered most likely to continue to reach moderate levels over the next couple of days. The expected arrival of a CME on Days 3-4 (12-13 July), followed by a HSS on Day 4, is expected to give a sharp decrease in flux during the second half of the period.

Electron fluence has plateaued and remains below Active levels (1e8 integrated pfu). This is likely to remain similar, perhaps with a slight decline through Days 1 and 2 (10-11 July), before a sudden drop off on Days 3-4 as the CME arrives. MOSWOC REFM guidance is showing a steady trend below Active, which is reasonable at first, although it won't be taking account of the likely CME arrival.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	10	20	20	10
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 5: MOSWOC REFM showing a declining trend below Active. REFM won't be taking account of any CME arrival.



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